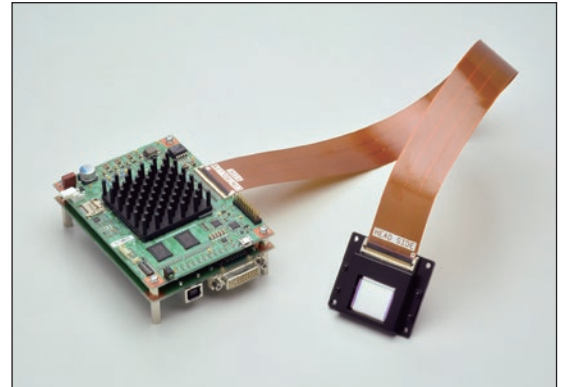


■ **Features**

- High diffraction efficiency
- High light utilization efficiency
- High linear modulation characteristic
- High power handling capability
- Compact and low-price
- Trigger function
- Easy to integrate cooling function to the LCOS-SLM head
- Various interfaces: DVI/USB/ serial communication/IO pins



■ **Applications**

- Laser processing
- Optical manipulation
- Wavefront aberration corrections
- Pulse shaping
- Optical test
- Metal 3D printing

■ **Outline**

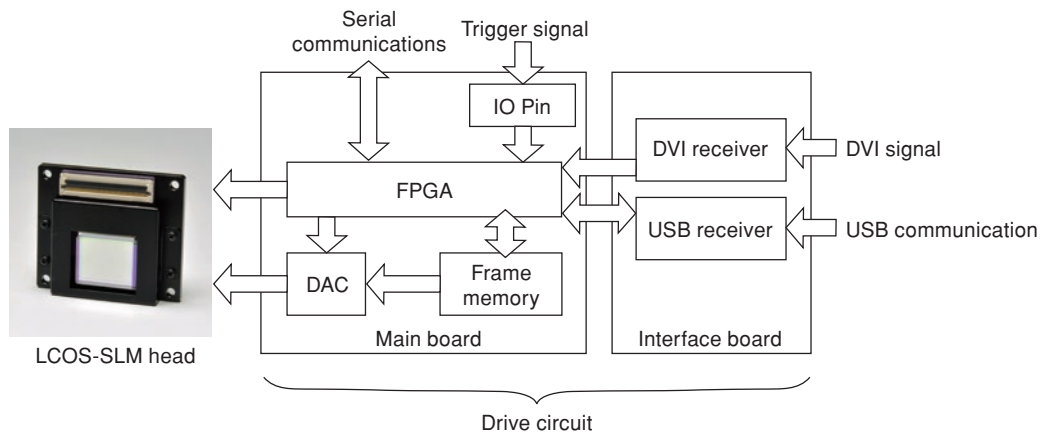
The X15223 series devices are LCOS-SLMs (Liquid Crystal On Silicon – Spatial Light Modulators) designed to be integrated into your devices. The LCOS-SLM head and driver circuit are connected by a flexible cable and can be easily installed in devices. In addition, the drive circuit is equipped with various interfaces, so you can select the most suitable interface for your system.

High-speed response and high-precision phase modulation are realized by directly controlling the liquid crystal (LC) with the voltage of the address part formed by applying CMOS technology.

The optimum optical design of the LCOS-SLM minimizes light loss to achieve high diffraction efficiency and high light utilization efficiency. In addition, high linear modulation characteristics can be obtained by digitally correcting distortion due to mirror surface distortion, non-uniformity of the thickness of the LC layer, and non-linear response of the LC.

In order to improve power handling capability, we also offer water-cooled models with a built-in water-cooled heatsink, and sapphire types using sapphire glass for the glass substrate.

Figure 1: Block diagram



LCOS-SLM X15223 series

■ Supported wavelength range

The X15223 series offers an extensive lineup to meet the needs of various wavelengths. All types have a glass substrate with an anti-reflection coating and a CMOS chip with a mirror. Recommended beam diameter ($1/e^2$) is 8 mm or more.

● Aluminum mirror type (-01/-07/-08)

The aluminum mirror type uses the reflection from the aluminum electrode on the CMOS chip and has a wide reflection band, so it can be used in a wide wavelength range.

● Dielectric multilayer mirror type (-02/-03/-05/-12/-13/-15/-16/-19)

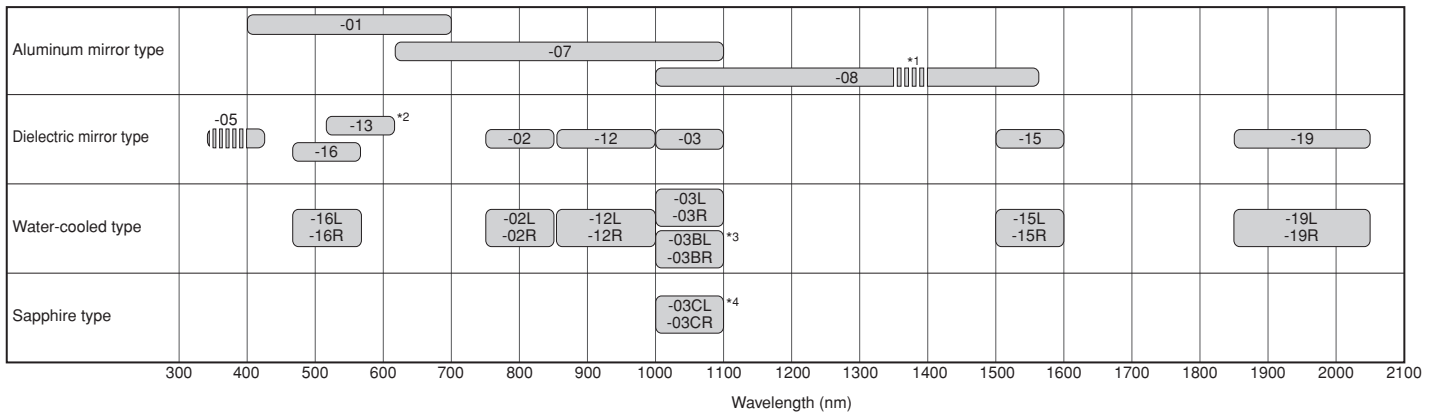
The dielectric multilayer mirror type has a specially designed dielectric multilayer film on the surface of the CMOS chip to support laser light sources of various wavelengths. Compared to the aluminum mirror type, the higher reflectivity achieved by the dielectric mirror decreases the internal absorption rate. High light utilization efficiency can be realized.

● Water-cooled type (-02L/-02R/-03L/-03R/-03BL/-03BR/-12L/-12R/-15L/-15R/-16L/-16R/-19L/-19R)

The dielectric multilayer mirror type head with a built-in water-cooled heat sink suppresses temperature rise due to laser irradiation and achieves high power handling capability.

● Sapphire type (-03CL/-03CR)

In addition to the water-cooled heat sink, sapphire glass is used for the glass substrate. As a result, the heat dissipation efficiency has been improved, leading to power handling capability of over 700 W.



*1 -08: In the wavelength range of 1350 nm to 1400 nm, absorption by the glass substrate reduces reflectance by approximately 5 %.

*2 -13 and -16: They can be used for 532 nm band lasers. The -16 has higher power handling capability for short pulse lasers than the -13.

*3 -03BL/-03BR: As for the average laser power, their power handling capability is higher than the -03L/-03R.

*4 -03CL/-03CR: They have a very high power handling capability of over 700 W and are suitable for metal processing.

■ Configuration

● Head

Parameter	X15223 series	Unit
Number of pixels	1272 × 1024	pixel
Pixel pitch	12.5	μm
Effective area size	15.9 × 12.8	mm
Fill factor	96.8	%
Weight	39 (Water-cooled type: 405 / Sapphire type: 443)	g

● Drive circuit

Parameter	X15223 series	Unit
Input voltage (DC)	16 ± 0.5	V
Power consumption (Typ.)	11.2	W
Input signal	Digital video interface (DVI-D) / USB-B (2.0 High-speed)	—
DVI signal format	1280 × 1024	pixel
DVI frame rate	60	Hz
Number of input signal gradations	256	level
Trigger signal voltage	High: 1.5 / Low: 0	V
Communication specification	USB-B (2.0 High-speed) / RS232C	—
Weight	180 (including accessories: 183)	g

LCOS-SLM X15223 series

■ Absolute maximum rating

(Ta=25 °C)

Parameter	X15223 series	Unit
Input voltage	16.5	V
Trigger signal voltage	1.8	V
Operating temperature *1	+10 to +40	°C
Storage temperature *1	-20 to +55	°C
Withstand pressure of water steam connector	0.3 (Water-cooled type)	MPa

*1 No condensation. Humidity may cause deterioration of characteristics, so be careful with the humidity.

* Exceeding the absolute maximum ratings even momentarily may cause a drop in product quality. Always be sure to use the product within the absolute maximum ratings.

■ Electrical and optical characteristics

Parameter	Readout light wavelength (nm)	Light utilization efficiency (Typ.) (%)	Rise time *1 (Typ.) (ms)	Fall time *1 (Typ.) (ms)
X15223-01	400 to 700	76	5	21
X15223-02/-02L/-02R	800 ± 50	97	33	85
X15223-03/-03L/-03R/-03BL/-03BR /-03CL/-03CR	1050 ± 50	97	27	83
X15223-05	410 ± 10	97	7	17
X15223-07	620 to 1100	80	9	73
X15223-08	1000 to 1550	86	13	145
X15223-12/-12L/-12R	850 to 1000	97	38	109
X15223-13	530 to 635	97	10	21
X15223-15/-15L/-15R	1550 ± 50	97	26	135
X15223-16/-16L/-16R	510 ± 50	97	11	33
X15223-19/-19L/-19R	1850 to 2050	97 *2	30 *2	155 *2

*1 Time required to change from 10 % to 90 % for 2 π modulation.

*2 Design value for a laser with an oscillation wavelength of 1950 nm.

* Lasers with the following wavelengths are used to measure light utilization efficiency, rise time, and fall time.

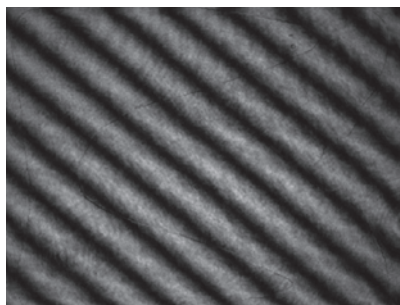
- Laser emission wavelength 633 nm (X15223-01)
- Laser emission wavelength 785 nm (X15223-02 series)
- Laser emission wavelength 1064 nm (X15223-03 series/-07)
- Laser emission wavelength 405 nm (X15223-05)
- Laser emission wavelength 1550 nm (X15223-08/-15 series)
- Laser emission wavelength 940 nm (X15223-12 series)
- Laser emission wavelength 532 nm (X15223-13/-16 series)

■ Operating characteristics

● High precision phase modulation

The X15223 series has high precision phase control and high diffraction efficiency, and is very suitable for holographic applications. Figure 2 (a) is a interferometer picture of the output wavefront with a flatness calibration. Figure 2 (b) is an example of a 1st order diffraction image obtained by reconstructing a computer generated hologram (CGH) using the Fourier transform optical system. Figure 2 (c) shows a clear Laguerre Gaussian (LG) beam of (0, 1) order.

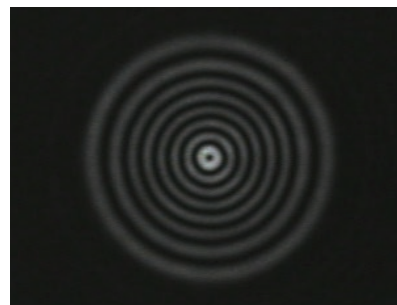
Figure 2: Output image examples



(a) Interferogram of output wavefront with calibration
1272 × 1024 pixels
RMS: 0.025 λ ($\lambda=532$ nm)



(b) Reconstructed image of CGH



(c) LG beam

LCOS-SLM X15223 series

●High diffraction efficiency

The X15223 series is a pure phase SLM with high precision phase control; therefore, it has high diffraction efficiency close to the theoretical values. Figure 3 shows images of diffracted spots when a multi-level phase grating is displayed on the X15223 series, and Figure 4 shows typical diffraction efficiency characteristics. Here, the diffraction efficiency is defined as I_1/I_0 , where I_1 is the intensity of the 1st order diffraction spot, I_0 is the intensity of the 0th order light when no pattern is displayed.

Figure 3: Diffracted spots images (typical example)

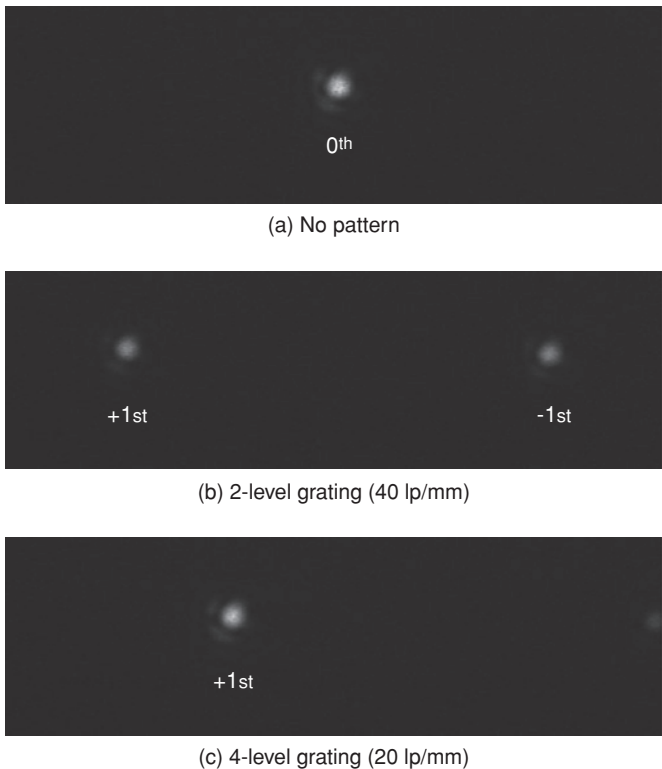
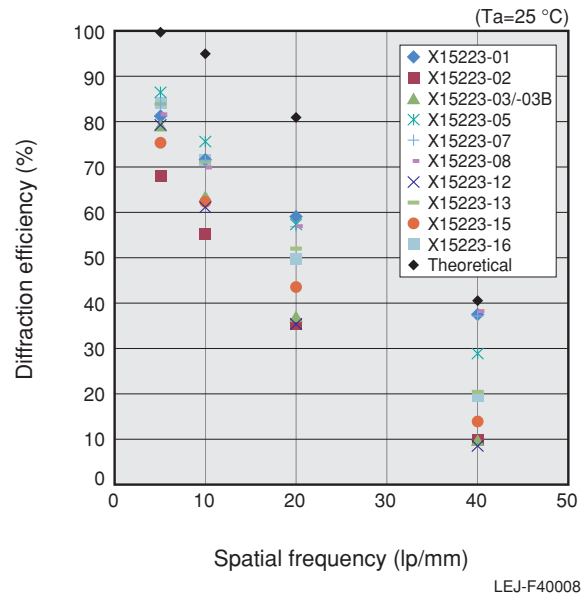


Figure 4: Diffraction efficiency (typical example)



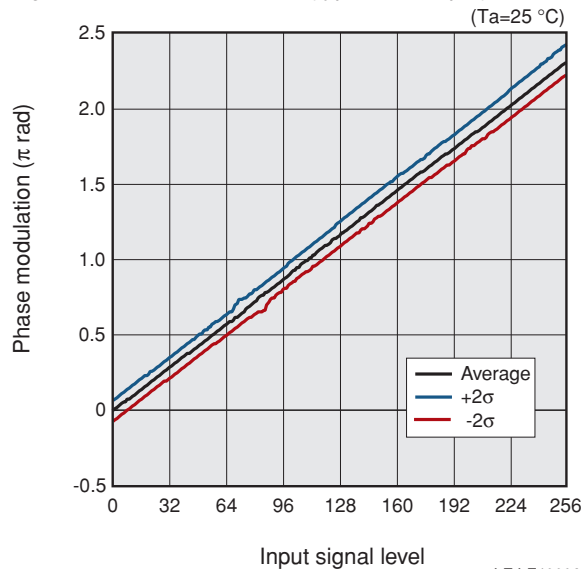
●High light utilization efficiency

The X15223 series have high light utilization efficiency, which is defined as the ratio of the 0th order diffraction light intensity to the input light intensity. The light utilization efficiency mainly depends on the reflectivity of the mirror, and the amount of diffraction loss caused by the pixel structure. We adopted advanced CMOS technology to make the diffraction loss smaller. As a result, the diffraction loss is less than 5 %. In particular, the -02/-03/-05/-12/-13/-15/-16/-19 series have very high light utilization efficiency thanks to the highly reflective dielectric mirror.

●High linear phase modulation characteristics

The X15223 series can achieve phase modulation of more than 2π radians over the 400 nm to 2050 nm readout wavelength range. Prior to shipment, each type is pre-calibrated at the factory to obtain high-precision and high-linear modulation characteristics for a specific wavelength range. Figure 5 shows typical phase modulation characteristics. A phase shift of 2π radians or more and a linear phase response are achieved. The phase modulation curve of 95 % of the pixels in the effective area is within $\pm 2\sigma$, which indicates that the variation is so small.

Figure 5: Phase modulation (typical example)



LCOS-SLM X15223 series

High power handling capability

Although the X15223 series achieves versatility and high reliability, there is a concern that characteristics may change depending on the peak power and average power of the incident light when irradiated with high power laser light. When the peak power is high, 2 photon absorption occurs in the LC layer, which leads to characteristic changes and damage. When the average power is high, a characteristic change occurs due to heat generation. The water-cooled type and the sapphire type with improved heat dissipation efficiency are effective in suppressing this characteristic change caused by heat generation.

Water-cooled type

When irradiating a laser with high average power, heat generation can be suppressed and power handling capability can be improved by using a water-cooled type equipped with a water-cooled heat sink. In addition, the -03 series used for wavelength range 1050 nm \pm 50 nm offers a lineup of -03BL/-03BR with improved power handling capability compared to the conventional -03L/-03R by reviewing the circuit-design of the pixel electrode. For example, they can be used for YAG lasers with an average power of up to 200 W.

Sapphire type

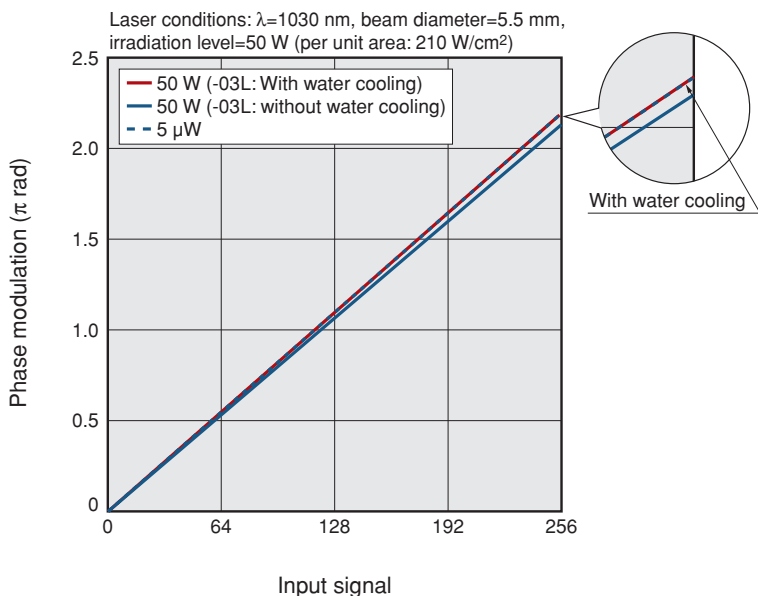
In addition to the water-cooled heat sink, the glass substrate is made of sapphire glass, which has approximately 30 times higher thermal conductivity than conventional materials. As a result, the heat dissipation efficiency has been improved. Furthermore, we have realized the power handling capability of over 700 W by enclosing high-thermal conductivity fillers inside LCOS-SLM packaging and optimizing the internal construction. It is possible to respond to high-power lasers required for metal processing.

Type	Type no.	Recommended average power
Aluminum mirror type	X15223-01/-07/-08	≤ 0.5 W *1
Dielectric mirror type	X15223-02/-03/-05/-12/-13/-15/-16/-19	≤ 10 W
Water-cooled type	X15223-02L/-02R/-03L/-03R/-12L/-12R/ -15L/-15R/-16L/-16R/-19L/-19R	≤ 100 W
	X15223-03BL/-03BR	≤ 200 W *2
Sapphire type	X15223-03CL/-03CR	≥ 700 W *2

*1 500 mW/cm² or less per unit area is recommended.

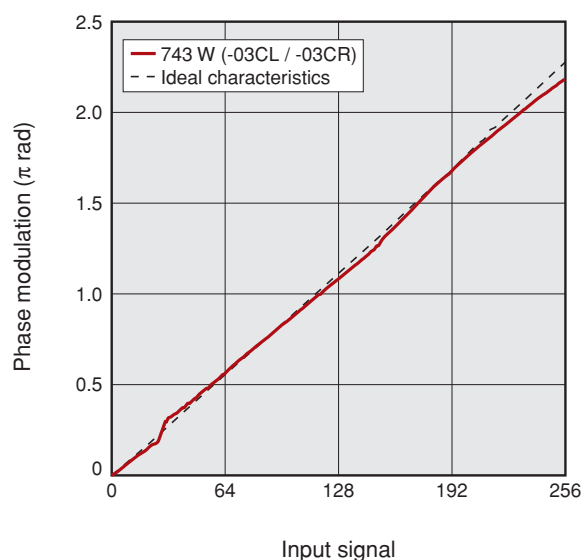
*2 As it also depends on irradiation conditions, please contact us for details.

Figure 6: Laser irradiation test result



* Phase modulation does not change even when exposed to high power laser.

Figure 7: Phase modulation characteristics of sapphire type

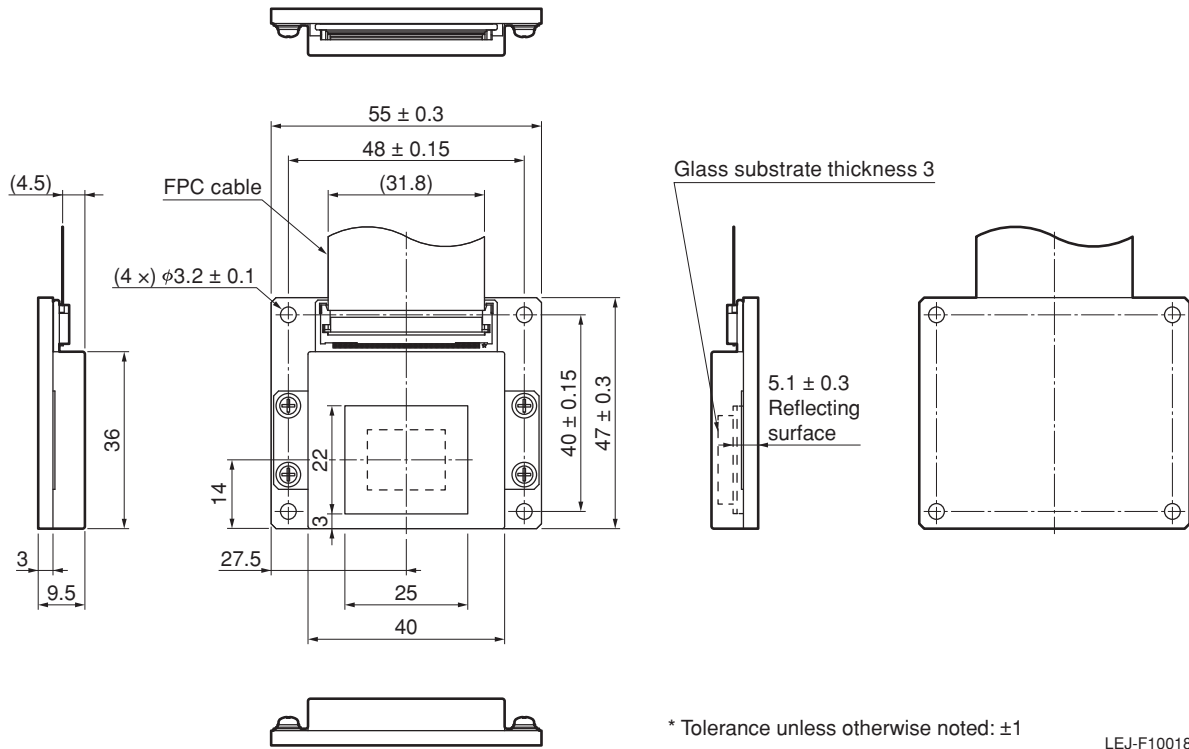


* The phase modulation characteristics depend on water cooling conditions. Please contact us for details.

LCOS-SLM X15223 series

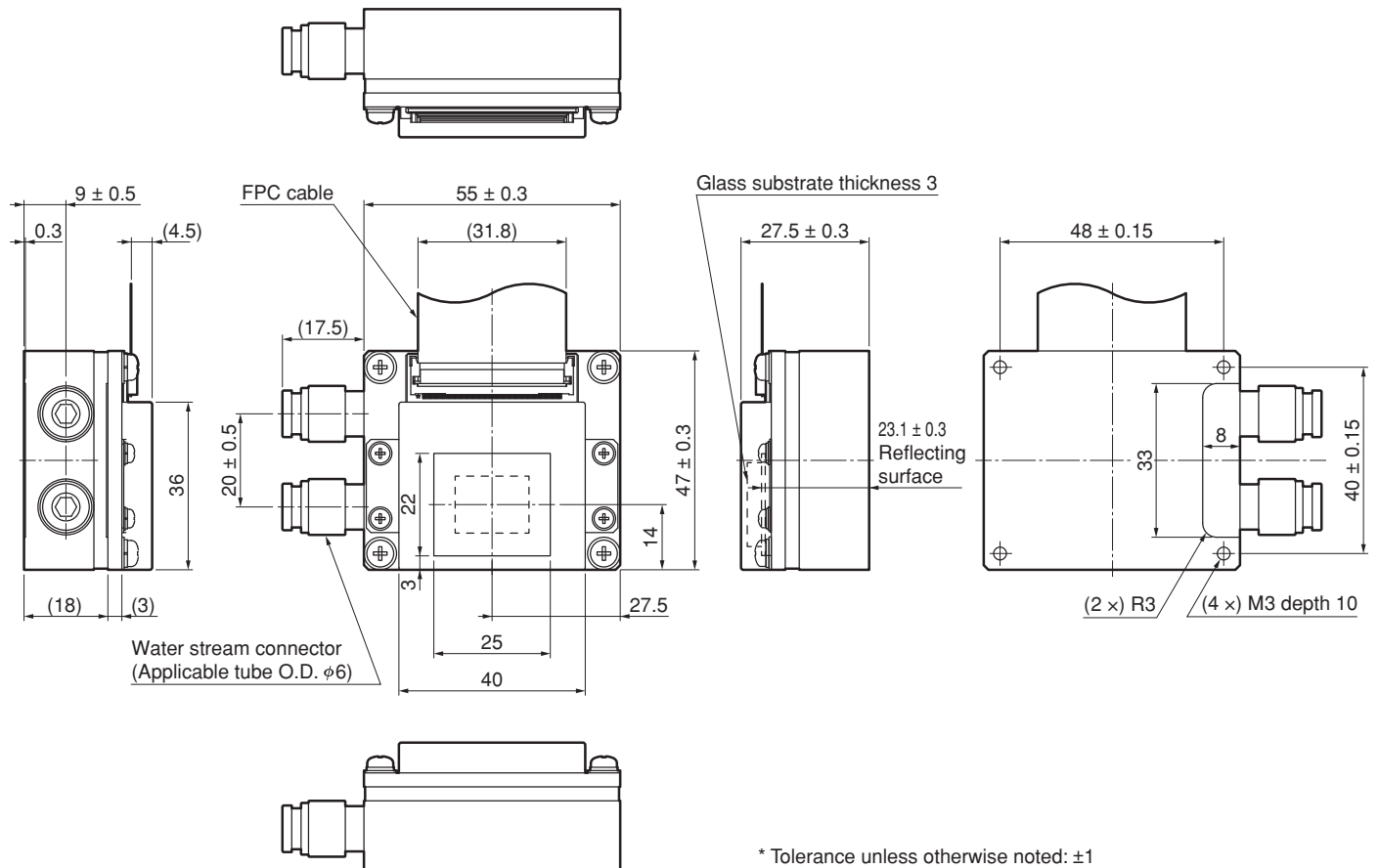
Figure 8: Dimensions (unit: mm)

●Head (X15223-01/-02/-03/-05/-07/-08/-12/-13/-15/-16/-19)



LEJ-F10018

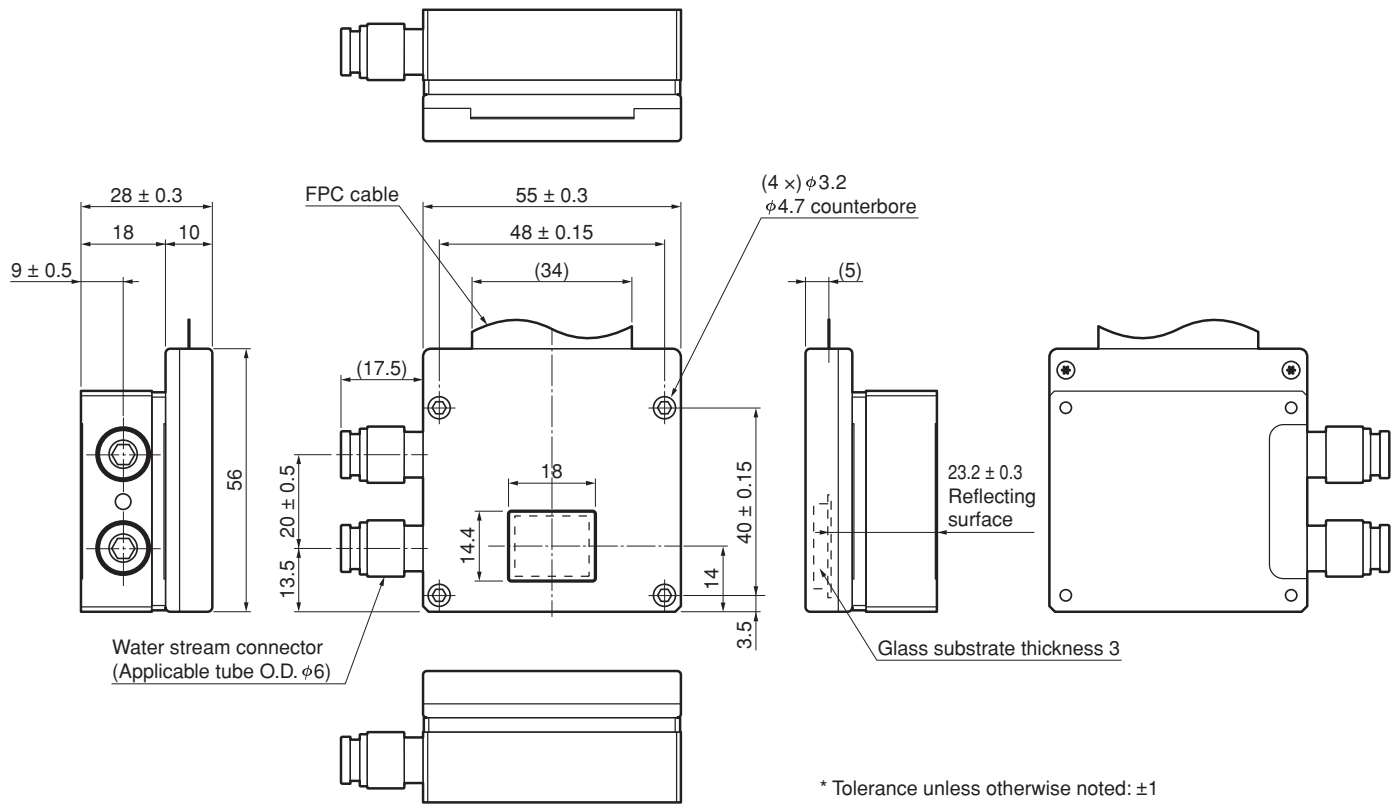
●Head (water-cooled type: X15223-02L/-03L/-03BL/-12L/-15L/-16L/-19L)



LEJ-F10019

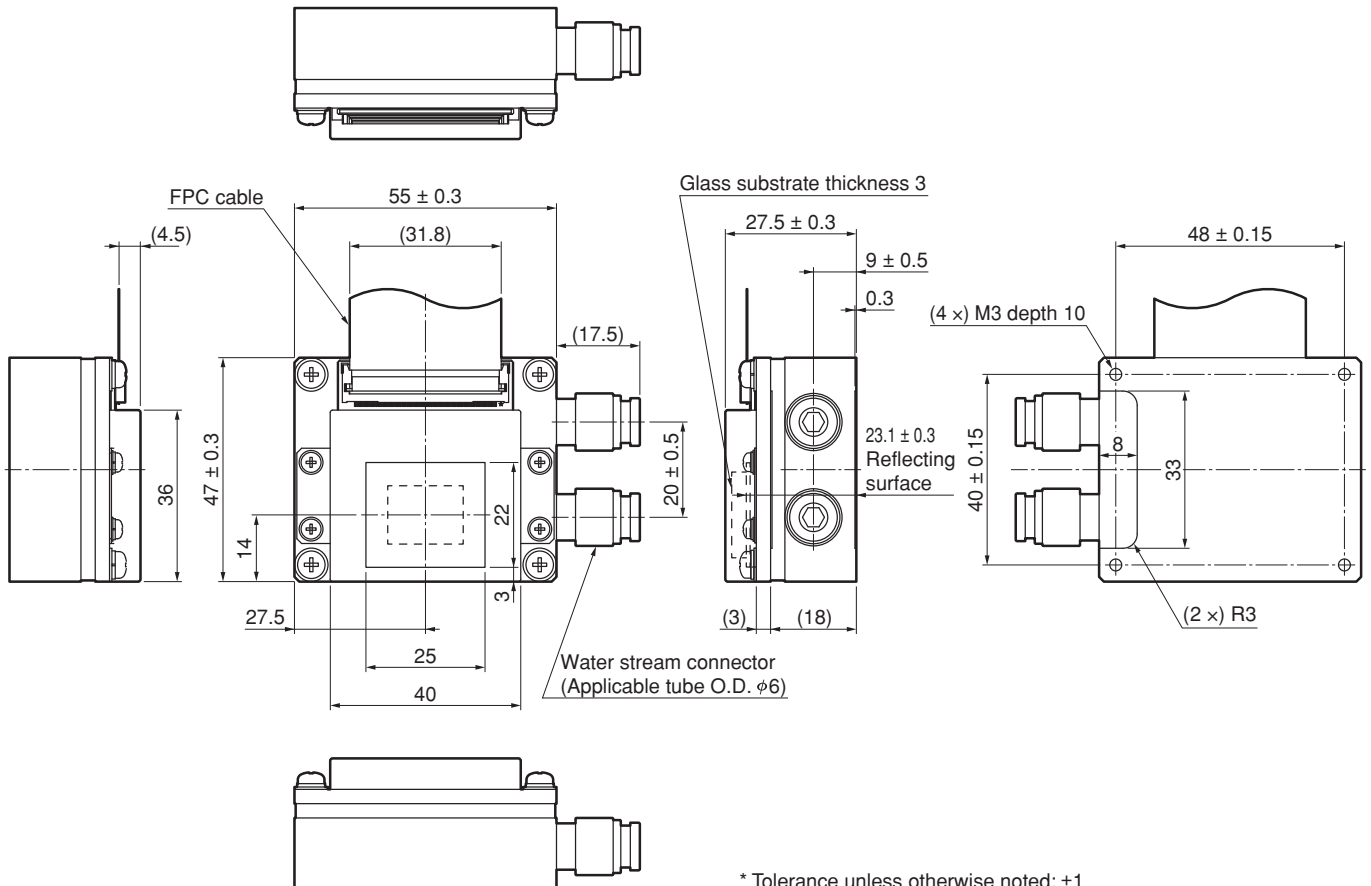
LCOS-SLM X15223 series

●Head (sapphire type: X15223-03CL)



LEJ-F10028

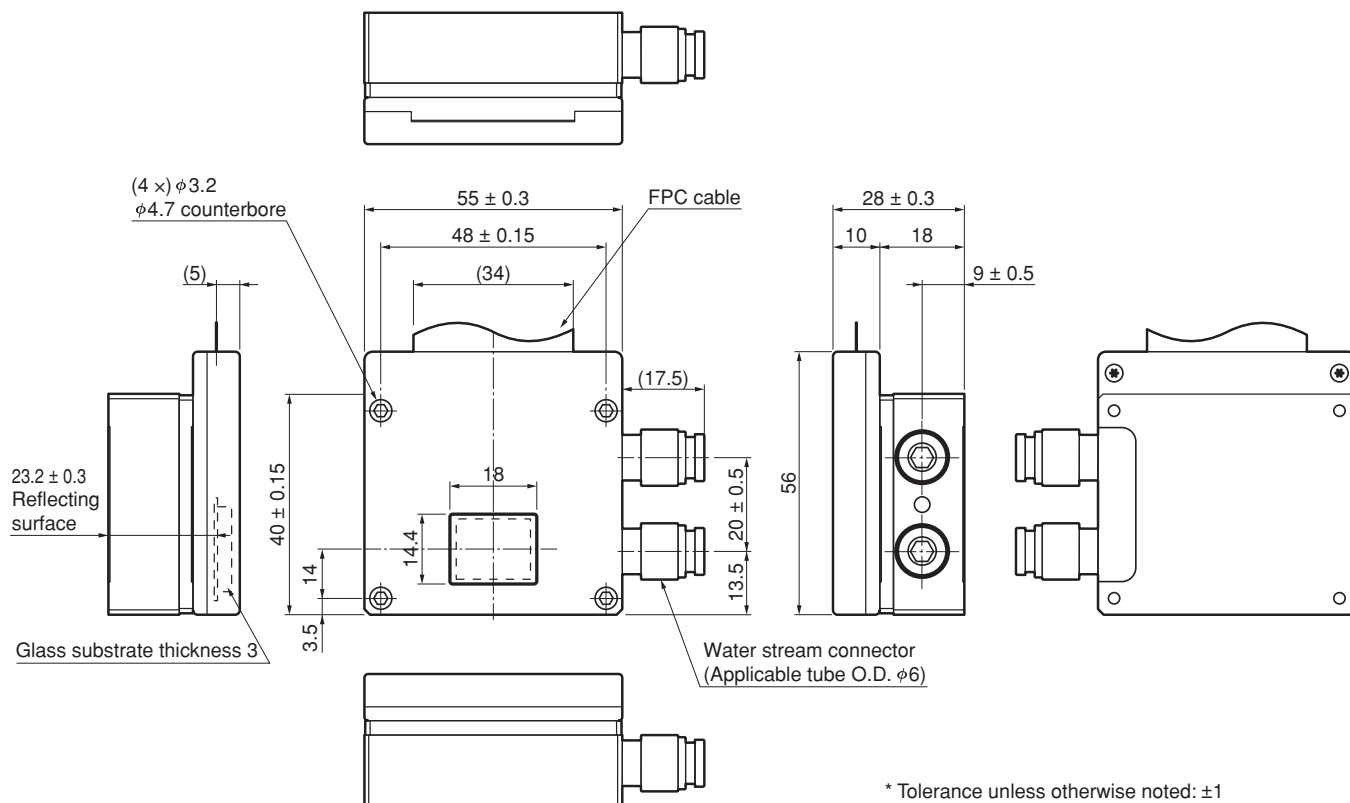
●Head (water-cooled type: X15223-02R/-03R/-03BR/-12R/-15R/-16R/-19R)



LEJ-F10020

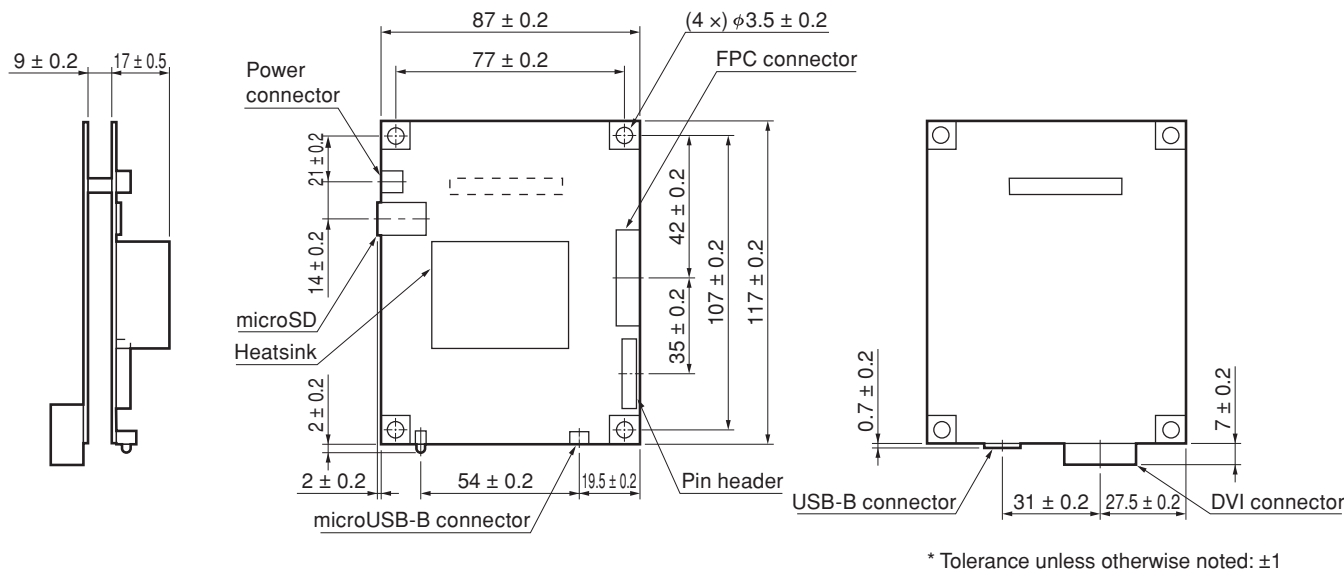
LCOS-SLM X15223 series

●Head (sapphire type: X15223-03CR)



LEJ-F10029

●Drive circuit



LEJ-F10021

■Precautions

· Product-related precautions

<https://www.hamamatsu.com/all/en/support/disclaimer.html>

●Information described in this material current as of December 2023. Specifications are subject to change without notice.

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Cat. No. LLAP3010E02
DEC. 2023 IP